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              AN/SQS-26 ANALYSIS PROGRESS REPORT FOR JUNE 1965.(U)
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Chief, Bureau of Ships
Department of the Navy
Washington 25, D. C.

Attention: Mr. E. H. Batey
⑥ Code 1631

Dear Sir: AN/SQS-26 Analysis Progress Report for June 1965.

The work done on SQS-26 Analysis during the first half of June
was primarily devoted to the preparation and organization of
material to be presented at the U. S. Navy Underwater Sound
Laboratory on June 17 and 18, 1965.

In general, the work on reverberation analysis and modeling,
studies of larger bandwidth pulses, receiver and beam forming
design concepts, display studies and redundancy effects on
beam patterns is complete and the results are being organized
into a summary report. The work on mutual interference study
was directed to the preparation for TRACOR's participation in
the sea tests in July and the analysis of recorded data taken
during those tests.

A separate summary report on reliability work undertaken on this
contract has been prepared and will be distributed shortly.

Enclosed is a report of pertinent work done during the month
of June.

Sincerely yours,

F. R. Mitchell
Project Manager

FRM:ejc

Attachment - Distribution list

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AN/SQS-26 ANALYSIS PROGRESS REPORT
for June 1965

TAPE ANALYSIS

The results of analysis of sea test data for wider bandwidth pulses, variations of target aspect in bottom bounce mode, convergence zone mode with variations in target depth and target aspect, are summarized here and will be reported in depth in a summary report which is in preparation. The results of the analysis of the linear correlator performance has been reported in TRACOR Document 65-217-C, "Sea Test Performance of a Real Time Linear Correlator" of 28 June 1965.

Wider Bandwidth Pulses. The analysis of thirty-eight analog tapes recorded aboard the USS Wilkinson (DL-5) during the period 18-21 August, 1964 to determine the extent of the energy splitting as a function of transmission bandwidth has been completed. Linear FM slide signals were transmitted with slide widths of 30, 100, 200, and 400 cps and duration of 1/2 second. The analysis indicates that the primary source of echo energy splitting is frequency spreading for the slide widths of 30, 100, and 200 cps. For the slide width of 400 cps both frequency and time spreading are apparently significant. The measured loss due to echo energy splitting is 3 dB for slide widths of 30, 100, and 200, and 4.3 dB for a slide width of 400 cps. Two conjectures can be made at this point: (1) the small effect of time spreading (multipath) may not be characteristic of typical operating conditions since the data were taken in Area Alpha, where the bottom characteristics are exceptionally good, (2) the loss due to frequency spreading is likely a result of the ship's own motion and if this is the case it is fundamentally removable. Verification of these conjectures will require further analysis.

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Convergence Zone. The analysis of Convergence Zone
performance for twenty-six analog tapes recorded aboard the
USS Wilkinson (DL-5) during the period 4-9 December, 1964,
has been completed. Three types of sea test data runs were
analyzed. These are as follows:

Type I is a long-range parallel run with the target
maintained at periscope depth and a range of about 74 kiloyards.
Measurements were made at beam, 45°, 20°, and bow aspects.

Type IA is the same as Type I except that the target is
at 400 feet depth and is at beam and 45° aspects only.

Type II is a long-range run on the target with the ships
starting at 80 kiloyards and closing within 10 kiloyards of
each other. The target is at beam, 45°, 20°, and bow aspects,
and is at periscope depth.

At this point there is considerable speculation as to the
extent of "hot spot" focusing of CZ sound paths which may yield
a false return that cannot be distinguished from a real echo.
We have not separated such false targets from the real targets
in our present analysis but have relied upon the average
statistics of a large number of data points to show the trends,
if any, toward any loss in performance due to aspect angle and
target depth.

The results of the analysis are summarized in Figure 1
which shows output (S/N) of the linear correlator relative to
0 dB input (S/N) as a function of aspect angle for the three
types of data. An average performance curve for all three types
of runs is also shown. The average curve shows that the expected
loss in performance is 1.5 dB at 45° aspect and 3 dB at bow
aspect. This loss in performance is relative to that measured
at beam aspect. This change in performance is attributed to the
echo energy splitting caused by increased target highlight
structure as the aspect angle decreases from 90° to 0°. The

Output (S/N) in dB

20 19 18 17 16 15

TYPE II
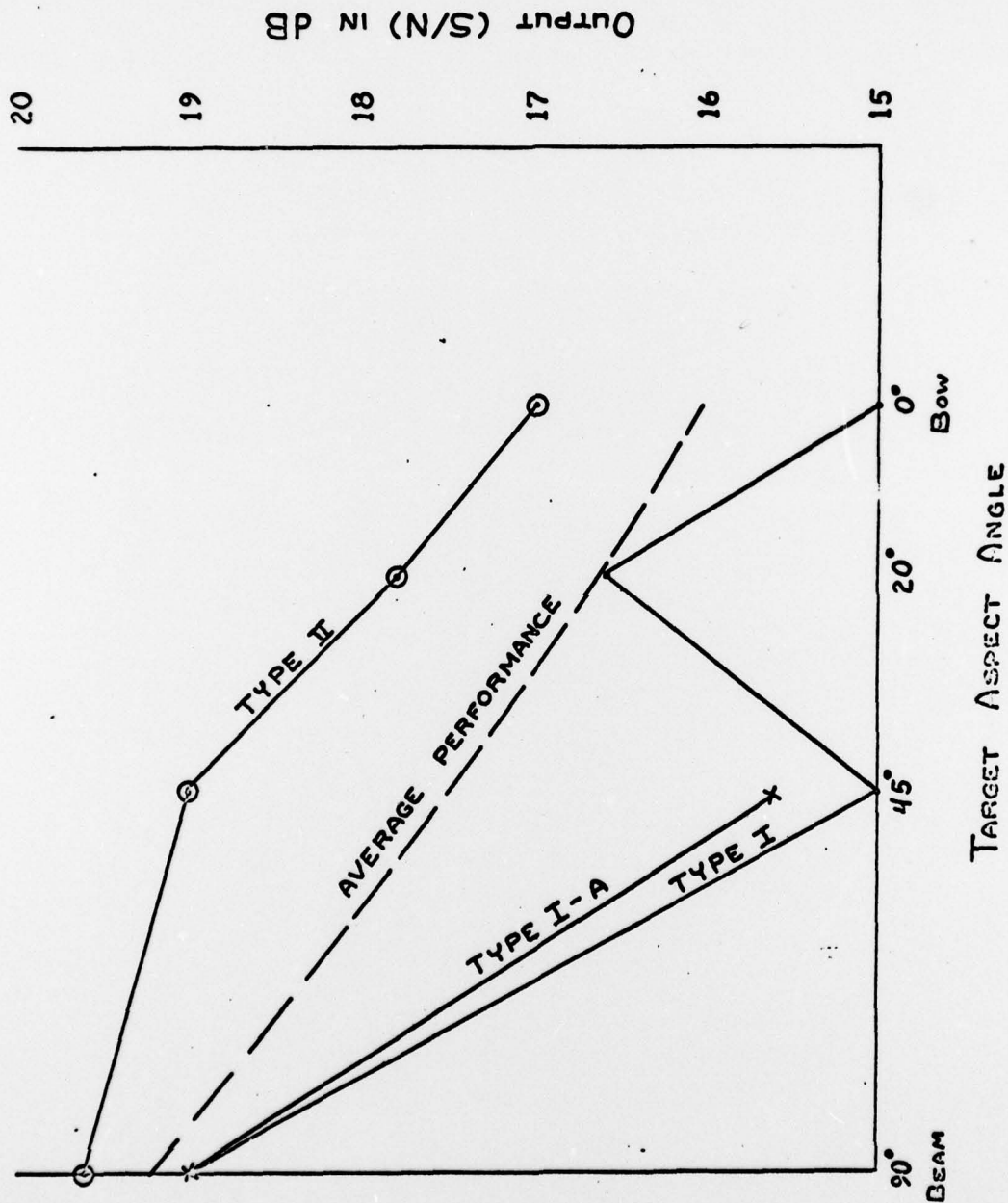
AVERAGE PERFORMANCE

TYPE I-A   TYPE I

90°
BEAM

45° 20° 0°
Bow

TARGET ASPECT ANGLE

Figure 1

Output (S/N) relative to 0 dB input (S/N) as a function of target aspect angle for CZ sea test data.

beam aspect performance of 19.2 dB output (S/N) relative to 0 dB input (S/N) is consistent with results obtained from bottom bounce data during other tests where the 100 cycles per second bandwidth transmission is used.

Target Aspect. Test data taken at sea was analyzed to determine the effect of target aspect angle on the structure of returning echoes for the bottom bounce mode. The transmitted signals are 1/2 second 100 cps FM pulses and were processed with a linear correlator. The ratio of the energy of the largest single portion of the echo which could be resolved by the correlator to the total energy of the echo was computed. These ratios are plotted as a function of target aspect angle in Figure 2.

REVERBERATION AND MUTUAL INTERFERENCE MODELS

Mathematical models for computing the intensity of reverberation and forward scattered sound (for mutual interference calculations) have been developed and programmed. These models will be discussed in detail in Summary Report III, now being prepared.

Future modification of the models include factors such as ray bending due to a variable sound velocity, are under consideration.

BEAM FORMING AND RECEIVER DESIGN CONCEPTS

A theoretical examination of the effects of quantization in a beam former is in progress. Since quantization into a small number of bits is a non-linear operation, the effect of this on the signal to reverberation ratio can determine the minimum number of bits usable in beam forming by digital methods. An extreme case of the potential difficulty is illustrated by the case of hard clipping. It is known that when the sum of two coherent signals of different frequencies is hard clipped (i.e. one-bit quantized), the stronger signal suppresses the weaker

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RATIO OF ENERGY IN LARGEST SINGLE RESOLVABLE ARRIVAL
TO ENERGY IN TOTAL ARRIVAL IN DB

TARGET ASPECT ANGLE

1/2 SECOND 100 CPS FM SLIDE
PROCESSED WITH A LINEAR CORRELATOR
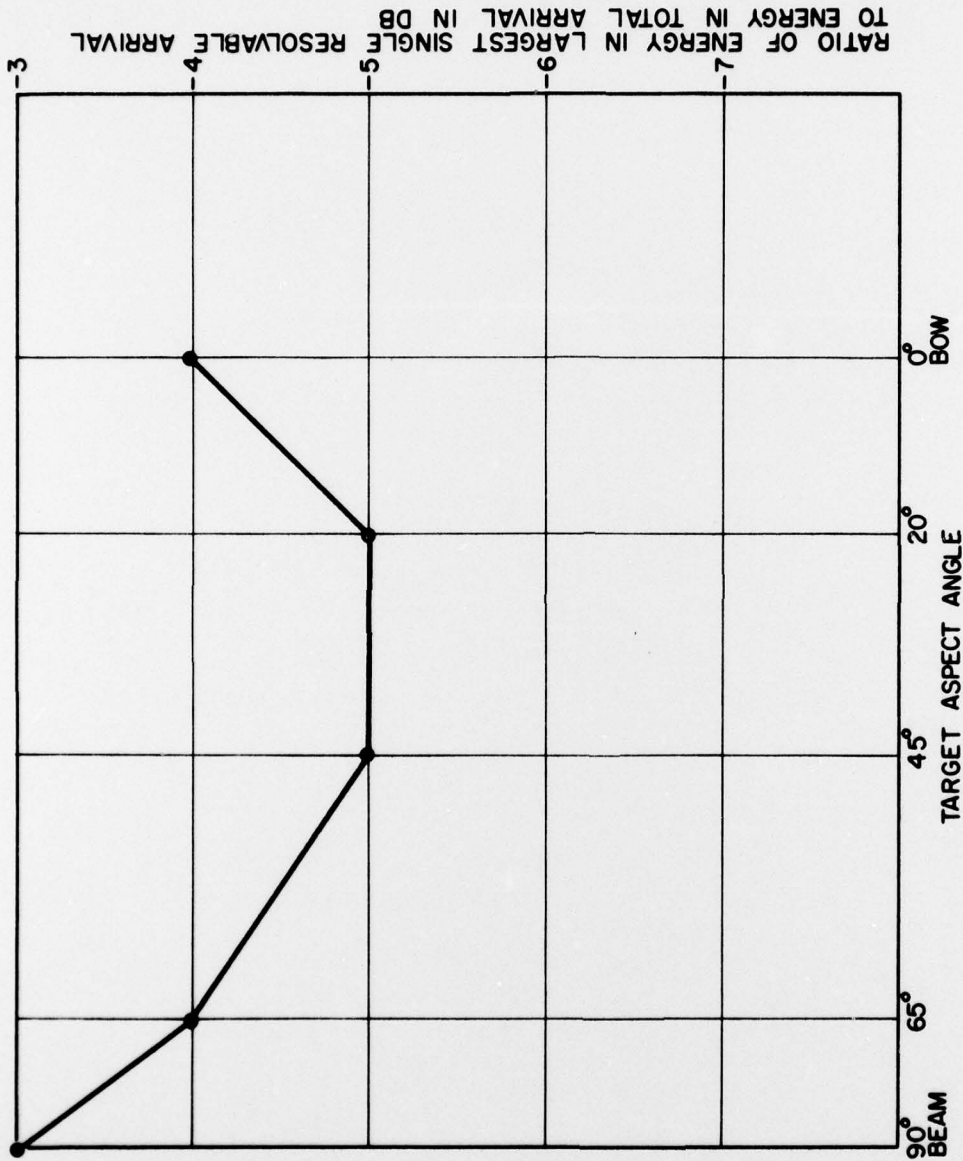
FIG. 2 - RATIO OF ENERGY IN LARGEST SINGLE RESOLVABLE ARRIVAL TO ENERGY
IN TOTAL ARRIVAL AS A FUNCTION OF TARGET ASPECT FOR BOTTOM
BOUNCE SEA DATA.

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by 6 dB. A similar effect could occur for 2 or 3 bit quantization but the degree of suppression may drop rapidly as the number of bits increases. A study of this effect therefore has a direct bearing on the performance of a digital beam former where partially coherent interference such as reverberation is involved. Ideally the number of bits used should be just sufficient to reduce the suppression to tolerable limits.

BOTTOM LOSS STUDIES (22012)

During this reporting period explosive acoustic data were obtained from the U. S. Naval Oceanographic Office and an analysis of these data similar to that carried out for the Alpine and Fasor studies was begun.

Data were collected by EG&G for NOO at twenty-three stations in the western North Atlantic. The EG&G Final Report,* shot and cruise logs were received with the magnetic tapes.

All tapes have been run for timing purposes, and the Bottom Bounce Geometry program has been revised to aid in the study. The analysis should be completed within the next month to determine bottom loss as a function of grazing angle for each of the twenty-three stations.

SINUSOIDAL BOTTOM MODEL

As a preliminary step toward developing a realistic model, an idealized steady state sinusoidal scattering model has been constructed via computer simulation techniques which involves a one dimensional rigid sinusoidal surface. The purpose of such a simplified initial study has been two-fold. First, the results compare favorably with existing analytical results, thereby

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*Acoustic and Geophysical Support Services, Final Report, Vols. I and II, Report No. B-2793, EG&G, 26 Feb. 1965.

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verifying the method of calculating the scattered pressure, and second, the study has provided insight into the effects of a roughness factor on the scattered pressure field.

The study will now be extended to a complex model which includes a finite pulse length, non-rigid, absorbing layered media, surface roughness factor for all boundaries, and shear waves in solid sub-layers.

DISPLAY ANALYSIS

During June film strips were generated for use in determining the optimum marking density for noise alone. In these film strips binary marking was employed, i.e. a constant intensity mark was made for each sample of noise or signal-plus-noise that exceeded a threshold. No mark was made if a sample did not exceed the threshold. The marking density was varied from 0.3 to 0.8 in 0.1 steps by varying the threshold. Observations of these film strips showed little, if any, variation in either probability of detection or probability of false alarm. Receiver operating characteristic (ROC) curves were prepared by requiring the observers to use a rating scale to indicate their confidence in decisions that a signal was present. These curves deviated little from the chance line resulting from guessing. The conclusion is that binary marking is not suited for displays in which only a six-to-twelve echo cycle history is presented.

A brief technical note (TRACOR Document 65-182-C) was prepared in which a comparison was made between the modified ROC curves for observers and those generated by the digital computer sonar simulator (computer clutter rate vs. probability of detection) for four signal-to-noise (S/N) ratios at the input to the display. It is shown that, for the six echo cycle history condition at least, the computer generated curves are better than the observer's curves (in the sense of showing a larger probability of detection at the same false alarm rate) at low

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probabilities of detection. Here, the computer can "see"
signals so small that only faint marks result on the display.
At high probabilities of detection the operators do better than
the computer, possibly because they are sensitive to a dynamic
range in the displayed data whereas the computer is restricted
to binary decisions.

EFFECT OF TARGET STRUCTURE ON DETECTION PROBABILITY FOR THE SQS-26

During June considerable progress was made on the analysis
of the effect of target structure on detection probability.
Preliminary results do not indicate any significant gain on the
average in probability of detection when target structure is
used in a post detection correlator.

The remainder of the work on this task will consist of
two efforts:

1. Attempt to improve the reference functions used
    to represent the echo structure.
2. Make use of a single stage image correlator in
    place of the double correlations which have been
    used in the study to date.

The first step is aimed at maximizing the processing gain.
This effort will be applied to examples where echo detail
presumably depends upon target structure and upon the insonifi-
cation geometry, e.g. the surface multipath triplet. It has
been noted that the spacings surface multipath triplet components
is not the same in a given echo. The observed deviation from
equality is consistent with the assumption that the echo point
for the direct return, the direct-surface return and the surface-
surface returns effectively come from different points on the hull.
The spacing differences are no more than 5 ms.

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The second item will be an attempt to carry out the image correlation directly on the raw data rather than in the two stage correlation used to date. The system employed thus far consisted of (a) a linear correlation using the transmitted pulse as the reference function and, (b) a magnitude correlation of the detected correlogram from (a) using an amplitude version of the image replica. The use of an image replica consisting of overlays of the transmitted pulse with delay spacings equal to the amplitude spacings employed in the amplitude image references will permit carrying out both steps in the procedure at the same time.

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